Stellar Populations as Building Blocks of Galaxies
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Chemical Abundances in Metal-Rich Bulge-like Stars

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Abstract. We have derived chemical abundances for Ca, Ti, Si, Mg, O, Na, Al, Ni, Co and Cr for a sample of stars with peculiar kinematics and probable origin near the bulge. Our sample stars are in the metallicity range $= -0.8 \leqslant$ [Fe/H] $\leqslant +0.6$ dex, and have small pericentric distances, Rp $\leqslant$ 3.5 kpc, small scale height, with $Z_{max} < 0.16$ kpc, and old ages, 9 to 11 Gyr. We have found that the abundance distributions of O, Mg and Al lie between bulge and both thin and thick disks distributions, i. e., with an enhanced pattern relative to thin and thick disk stars, and an underabundant behavior compared to bulge stars. [Na/Fe] ratios ovelarp the bulge distribution in the metal-poor tail, and show similar values compared to thin and thick disk stars for the super-solar metallicity range. Ca, Ti and Si values are similar to those of the thick disk stars in the metal-poor range, while an underabundant behavior is seen relative to thin disk stars for metallicities [Fe/H] $> +0.3$ dex. Compared to bulge stars, such elements are deficient in our sample stas. For the iron-peak elements Cr and Ni we have found a slightly overabundant behavior relative to both thin and thick disks distributions in the metal-poor range, and a smooth decreasing trend for [Cr/Fe] for stars in the supersolar regime. [Co/Fe] ratios track the solar value in the metal-poor range, and show an underabundant behavior relative do thin disk stars for metallicities [Fe/H] > 0.0 dex.

Keywords. stars: abundances – stars: late-type – Galaxy: evolution – Galaxy: bulge

1. Introduction

The structure of our galaxy appears increasingly complex. Stellar and gaseous substructures have been observed within the known main components (bulge, thin disk, thick disk and halo) such as the bar, streams and comoving-groups, flares and a warp. Among these substructures, we have found a nearby group of high-velocity stars, with highly excentric orbits and probable origin in the inner parts of the Galaxy. From previous works we have found for a sample of intermediate metallicity stars ($-0.8 \leqslant$ [Fe/H] $\leqslant +0.4$ dex) of this group a different chemical composition compared to the average stars pertaining to the solar-neighborhood (Pompéia *et al.* 2002, 2003). In the present work we report our first results for a sample of metal-rich stars of such group that we have called $bulge - like$ stars. With this we intend to shed light on the origin of this population and to place it in the global scenario of the Galaxy.

2. Observations and Stellar Parameters Determination

The observations were carreied out at the 1.52 m telescope of ESO, La Silla, in September 1999, using the FEROS spectrograph with the standard star+sky

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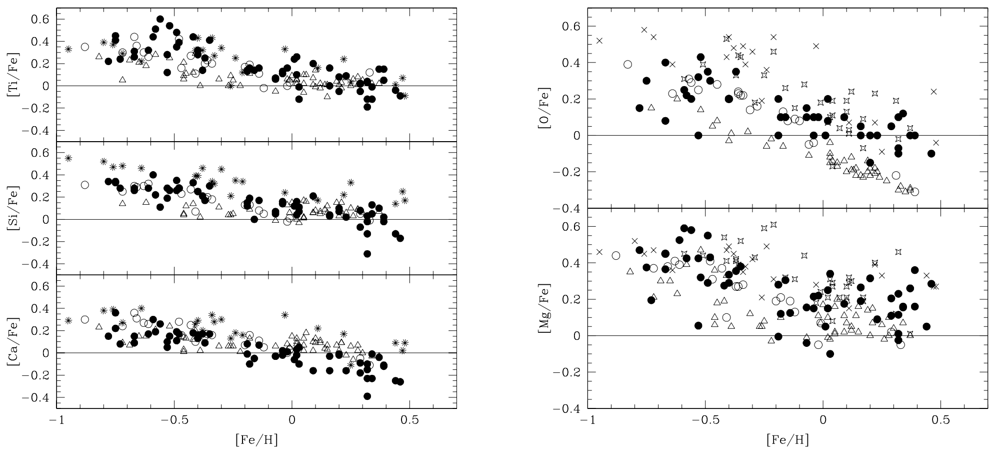

Figure 1. Left: (1a) [α/Fe] vs. [Fe/H] for Ca, Ti and Si. Symbols: filled circles - our sample stars; open circles - thick disk sample of Bensby *et al.* (2005); open triangles - thin disk sample of Bensby *et al.* (2005); asterisks – bulge data of Fulbright *et al.* (2006).**Right: (1b)** [α/Fe] vs. [Fe/H] for O and Mg. Symbols are the same as in Fig. 1a, except that data for oxygen for thin and thick disks data are from Bensby *et al.* (2004), and stars are from bulge data of Lecureur *et al.* (2006).

configuration. The spectral coverage is 356 – 920 nm, with a R = 48,000 resolution. Data reduction was performed using the ESO pipeline package for reductions of FEROS data in MIDAS environment.

Stellar parameters have been calculated using the EW (equivalent width) measurements of iron lines: i) the effective temperature of the stars have been derived by requiring the excitation equilibrium of the Fe I lines; ii) gravities and metallicities have been inferred by forcing the ionization equilibrium of Fe I and Fe II, and also checking with the Ti I and Ti II lines; and iii) microturbulence velocities have been obtained by requiring no slope in the A(Fe I) vs. EW plot.

3. Abundance Analysis

Chemical abundances for Ca, Ti, Si, Cr, Ni, Al and Na have been obtained from the EW of the lines. Abundances for O, Mg and Co have been inferred by fitting the synthetic to the observed spectrum. The hyperfine structure has been taken into account for Cobalt.

4. Discussion

In Figs. 1 to 2 we compare our results to those for the galactic thick and thin disks and to bulge data (the references are given in the plots). We have found that Ca, Ti and Si show similar behavior, with a match to the galactic thick disk for metalicities lower than solar, and with an underabundant pattern for super-solar metallicies, with a possible decreasing trend for [Fe/H] > +0.3 dex. Therefore our sample stars depict a steeper decline of [α/Fe] vs. [Fe/H] for these elements when compared to thick and thin disk stars. Relative to bulge stars, our data are deficient for such elements. We have found for O, Mg and Al an intermediate behavior between the bulge distribution and the distributions of both thin and thick disk stars. Such behavior is clearer for [O/Fe] and [Al/Fe] than for [Mg/Fe], which shows a higher scatter. Sodium overlaps the bulge

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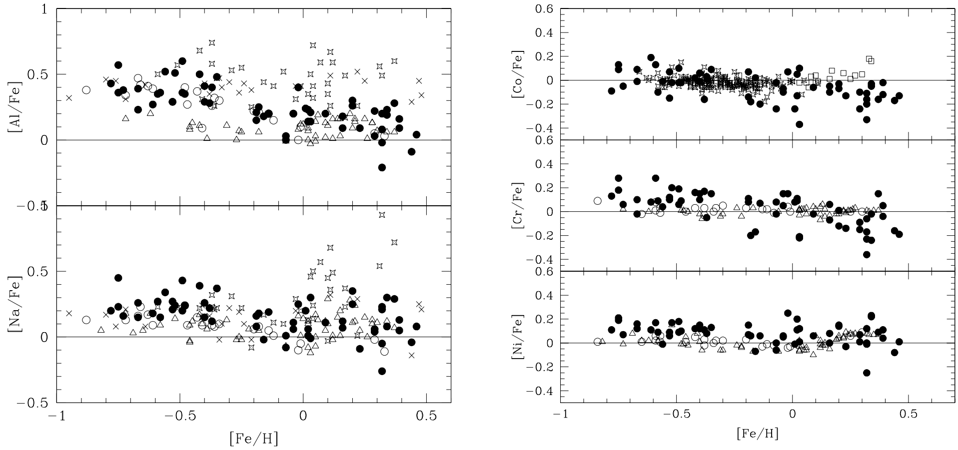

Figure 2. Left: (2a) [Al/Fe] vs. [Fe/H] and [Na/Fe] vs. [Fe/H]. Symbols: filled circles – our sample stars; open circles – thick disk sample of Bensby *et al.* (2005); open triangles – thin disk sample of Bensby *et al.* (2005); asterisks - bulge data of Fulbright *et al.* (2006); stars – bulge data of Lecureur *et al.* (2006). **Right: (2b):** [iron-peak/Fe] vs. [Fe/H] for Ni, Cr and Co. Symbols: filled circles – our sample stars; open circles – thick disk sample of Bensby *et al.* (2005); open triangles – thin disk sample of Bensby *et al.* (2005); open squares – disk stars of Thóren & Feltzing (2001); stars – thin disk stars of Reddy *et al.* (2003).

distribution in the metal-poor range, while for the supersolar metallicity stars, it shows similar values to those of the thin disk. The iron-peak elements Ni and Cr show enhanced abundance ratios relative to both thick and thin disk distributions in the subsolar range, while [Co/Fe] match the thin disk distribution of Reddy *et al.* (2003). For the metal-rich stars we have found that Ni ratios track the solar value, while [Co/Fe] and [Cr/Fe] are deficient, both also indicating a decreasing trend for stars with [Fe/H] $>$ +0.3 dex. From the chemical point of view, the $bulge - like$ stars are different when compared to both thin and thick disks stars, and also to bulge stars, hinting for a different star formation history, possibly faster than that of the thin and thick disks, but not as fast as that of the bulge.

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Discussion

RENZINI: Did you find any correlation of the chemical abundances with the "age groups" of M. Grenon?.

POMPEIA: The present sample is an age group, with ages of 9-11 Gyr, and also a kinematical group.

NORDSTRÖM: You have chosen excentricitiees e >0.25 and metallicities [M/H]>0.25. If you choose successively lower eccentricities would you expect a continuous chemical trend towards solar chemical characteristics?.

POMPEIA: I think so. It is an interesting test.

ANDERSEN: How were the ages of these stars determined – from isochrones or other criteria?.

POMPEIA: From isochrones.

PELETIER: I wonder whether your sample of bulge-like stars might look like a disk-like sample at 5 Kpc, since most disk samples come from solar neighbourhood samples.

POMPEIA: I will check it.

During an excursion (f.l.t.r.): Evan Skillman, Javier Cenarro, Adriana de Lorenzo Cáceres, Doug Geisler, Philippe Prugniel, Mike Beasley, Lidia Makarova, Kyros Vazdekis.

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